FINAL TECHNICAL REPORT

TO

OFFICE OF NAVAL RESEARCH
800 N. QUINCY STREET
ARLINGTON, VA 22217-5000

ON

ONR DISTINGUISHED OCEAN SCIENCE EDUCATOR IN OCEAN NUMERICAL MODELLING

ONR GRANT NO. N00014-90-J-1444

SUBMITTED BY

DR. JAMES J. O'BRIEN, PRINCIPAL INVESTIGATOR
THE FLORIDA STATE UNIVERSITY
MESOSCALE AIR-SEA INTERACTION GROUP
020 LOVE BUILDING
TALLAHASSEE, FL 32306-3041

JUNE 21, 1994

AUTHORIZED REPRESENTATIVE:

James J. O'Brien

Dr. James J. O'Brien
Professor & Principal Investigator
Mesoscale Air-Sea Interaction Group
The Florida State University
Tallahassee, FL 32306-3041
Telephone No.: (904)644-4581
Fax No.: (904)644-4841

FINAL REPORT

ONR "OCEAN SCIENCE EDUCATOR IN NUMERICAL MODELING"

Four projects, all leading to publication, were supported by the ONR Educator Award.

1) The first is an investigation of Gulf Stream dynamics using concepts of chaotic transport. A Gulf Stream-like meandering current is kinematically modeled using a jet-like streamfunction. The streamfunction has been used by other authors to investigate geophysical fluid motion. Under suitable parameter values a "front" exists along the velocity maximum across which there is no transport, but with mixing occurring on either side. An analogous barrier exists in the Gulf Stream, but appears to fade with depth, as shown by others. The conditions for mixing across the model front are studied using the Chirikov overlap criterion which indicates the front breaks down for meander amplitude above a critical threshold that is inversely dependent on the ratio of meander phase speed and current speed, c/U.

It appears that the increase in cross-frontal mixing in the deeper levels of the Gulf Stream is the result of current meandering and the decrease of current velocity with depth. The mechanism is the interaction of different meander modes traveling along the Gulf Stream.

2) The second topic was a discussion of the sensitivity of objective techniques to parametric variations. Solutions of some objective analysis techniques are known to depend upon the subjective values of internal parameters. The change in the solution per change in the parameter is the sensitivity. Parameters with low sensitivity can be varied with large increments during preliminary searches for

near-optimal parameter values. Only terms with high sensitivity must be thoroughly investigated once the parameters are determined to be close to optimal. Both absolute and relative sensitivities are discussed and a sensitivity-based definition of the solution uncertainty is proposed. The sensitivity of direct minimization analysis to parametric variation is evaluated using a set of "response function" that characterize different aspects of the solution.

Two examples are used to illustrate the usefulness of the technique. Both involve measurements of air-sea quantities (e.g., wind stress and latent heat flux) from a variety of data sources using a direct minimization technique. The examples demonstrate that sensitivity analysis is capable of quantifying regional sensitivities as well as indicating the magnitude and relationship between the various parameters.

3) The third topic is an early application of wavelet methods to equatorial waves. Wavelet analysis is a relatively new technique that is an important addition to standard signal analysis methods. Unlike Fourier analysis which yields an average amplitude and phase for each harmonic in a data set, the wavelet transform produces an "instantaneous" estimate or local value for the amplitude and phase of each harmonic. This allows detailed study of nonstationary spatial or time-dependent signal characteristics.

We demonstrate the usefulness of the transform by studying the dispersion of Yanai waves in a reduced gravity equatorial model. The group velocity is measured directly over a finite range of wavenumbers by examining the time evolution of the transform. The results agree well with linear theory at higher wavenumber but the measured group velocity is reduced at lower wavenumbers, possibly due to interaction with the basin boundaries.

4) **The fourth study is an application of wavelet analysis. Two-year sea-surface temperature time series of satellite data at two sites in the equatorial Indian Ocean are examined for oscillations with periods of 2-70 days. The wavelet transform of the signals reveals a changing wavelet spectrum between August 1987 and** November 1987 in the 10-30 day range, while the same time period in 1988 shows a relatively fixed spectrum. At 3 degrees latitude and 53E longitude the 1987 wavelet coefficients with scales 10-30 days have about twice the amplitude they have in 1988. At 3 latitude and 56E longitude the 1987 waves have roughly half the amplitude as the 1988 waves. Activity with wavelet spectral peaks at periods near 12 says often precede these waves.

PUBLICATIONS
on
ONR GRANT NO. N00014-90-J-1444

Meyers, S.D., Cross-frontal mixing in a meandering jet, ***J. Phy. Ocea., 24, 1641-1646, 1994.***

Meyers, S.D., C. S. Jones, D. M. Legler, K. F. Miles and J. J. O'Brien, The sensitivity to parametric variation in direct minimization techniques, ***Mon. Wea. Rev., 122, 1632-1639, 1994.***

Meyers, S.D., B. G. Kelly and J. J. O'Brien, An introduction to wavelet analysis in oceanography and meteorology: with application to the dispersion of Yanai waves, ***Mon. Wea. Rev., 121, 2858-2866, 1993.***

Meyers, S.D. and J. J. O'Brien, Spatial and temporal 26-day SST variations in the equatorial Indian Ocean using wavelet analysis, ***Geophy. Res. Letters, 21, 777-780, 1994.***

O'Brien, James J. and F. Parham, Equatorial Kelvin waves do not vanish, ***Monthly Wea. Rev., Vol. 120, No. 8, August 1992.***